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# PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.: —H 05 b 3/82

## COMPLETE SPECIFICATION

### Continuous Flow Electric Liquid Heater

I, RONALD EDWARD FRANCIS, a British Subject of Stonebench House, Stonebench, in the County of Gloucester, formerly of 62, Reform Street, West Bromwich, in the County of Stafford, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heaters of the kind for receiving liquid from a supply thereof admitted through an inlet valve and subsequently caused to flow over an electric heating element prior to delivery from an outlet.

Such heaters are hereinafter referred to as being of the kind specified.

More particularly the invention relates to domestic water heaters for supplying a continuous flow of hot water as and when required from a source of cold water without intermediate storage.

The object of the invention is to provide a new or improved construction of heater of the kind specified which is efficient and safe in use whilst being compact in form.

According to the present invention a heater of the kind specified is characterised in that the liquid flows through a tube (hereinafter referred to as the heating tube) in close thermal contact with the electric heating element which comprises a length of resistance wire insulated by mineral substance contained in a thin walled metal tube coaxially arranged within the heating tube, the supply of electricity to the heating element being controlled by a pressure sensitive switch device which is responsive to the pressure of liquid within the heater.

The heating element may be retained centrally in the heating tube by a continuous or interrupted fin which is disposed helically around the heating element and in contact with the latter and with the inner surface of the heating tube.

Preferably the fin comprises a length of wire of circular shape in cross-section which is wound around the heating element.

The diameter of the heating element may be approximately half the internal diameter of the heating tube, and the length of the former may be slightly greater than that of the latter so that it projects out of the latter at each end for a short distance such that electric connections may be made at the projecting parts, the liquid entering and leaving the heating tube in directions substantially at right-angles to the longitudinal axis of the latter.

The pressure sensitive switch device may be a switch means of the "normally open" type having an operating member in operable contact with a displaceable or deformable diaphragm in a chamber connected to an inlet pipe which incorporates the inlet valve and is formed with a fitting for connection to the liquid supply pipe, and the arrangement being such that the heating element is not energised until a predetermined minimum pressure is exerted on the diaphragm.

The heater may be provided with a pressure relief valve situated at or near the outlet such that if an excessive pressure arises within the heater due either to blockage of the outlet pipe or over heating of the liquid to form a vapour lock this valve is opened to relieve the pressure.

Preferably the heating tube is formed into a coil, loop, frame or like apertured heating unit and disposed in the aperture thus afforded is a control unit comprising the inlet valve and the pressure sensitive switch device.

The invention will now be described by way of example with reference to one specific example of a continuous flow domestic electric water heater as illustrated in the accompanying drawings wherein:—

FIGURE 1 shows a front elevational view

of a water heater with the cover removed, FIGURE 2 shows a transverse cross-section through a heating tube in the water heater, on the line II—II of Figure 1,

5 FIGURE 3 shows a longitudinal cross-section through the heating tube, on the line III—III of Figure 1,

FIGURE 4 shows a diametral cross-section through the heater on the line IV—IV of Figure 1 with the cover in place,

10 FIGURE 5 shows a cross-section through a connecting piece at one end of the heating tube, and

FIGURE 6 shows a partial cross-section on the line VI—VI of Figure 4.

15 The domestic water heater illustrated has a shallow cylindrical body 10 comprising a cylindrical wall 10a and a plain circular back wall 10b adapted for mounting on a vertical supporting surface with the axis of the cylinder substantially horizontal. Two screw holes such as that indicated at 10c in the back wall permit of securing of the body thereto by screws. Inlet and outlet apertures 11 and 12 respectively are provided in the downwardly presented part of the cylindrical wall for connection to water supply and water outlet pipes (not shown). A circular cover 13 is formed with a peripheral flange 13a and is adapted to fit over the free periphery of the cylindrical wall 10a. Two holes 13b and 13c are formed in the central region of this cover, respectively for a control spindle 14a of an inlet supply valve 14 contained within the body, and for the accommodation of a neon pilot light 15. The bulb of the pilot light is located freely in a tubular sleeve 15a formed of a plastics material coloured red, the sleeve itself being mounted in the hole 13c. Thus the cover 13 may be removed from the body 10 without the necessity of disconnecting the wiring to the pilot light 15.

20 The inlet supply valve 14 is housed in a casing 16 formed integrally as a casting with the inlet pipe 17 which extends vertically upwardly from a connection 11a situated in the inlet aperture 11. The inlet pipe 17 is formed with a branch 17a substantially at right-angles to the length of the pipe 17 after the inlet valve 14. A short length of copper tube 18 is connected between this branch and the inlet end of a length of thin walled copper tubing which serves as a heating tube 20 in which the water is to be heated, the diameter of this heating tube being somewhat greater than that of the connecting tube 18. An outlet tube 42 is connected between the outlet end of the heating tube 20 and a T-piece 45 having a connection 13a for an outlet pipe (not shown) in the outlet aperture 12.

25 Formed integrally on the upper end of the inlet pipe 17 is one part of the casing of a diaphragm chamber 21. The diaphragm

chamber comprises two circular discs 22a and b, each provided with an annular flange 22c through which a plurality of screw receiving holes 22d extends. The discs are assembled with their flanges inwardly presented so as to define the chamber 21 and grip the outer peripheral margin of the diaphragm 23 which extends across the chamber. Screws 24 passing through the holes 22d serve to secure the discs together and to hold the diaphragm firmly.

70 The diaphragm 23 may be made of natural or preferably synthetic rubber. One suitable material, for example, is a laminate of synthetic rubber and polytetrafluoroethylene which is tested to withstand a pressure of up to 150 pounds per square inch. However other synthetic plastics materials could be employed particularly in a heater to be used for some liquid other than water or if the operating pressure of the liquid was to exceed the normal domestic water supply pressure (for example, a pressure greater than 50 to 60 per square inch).

75 A cylindrical plunger 25 rests on the upper surface of the diaphragm 23 at its centre and passes upwardly through an aperture 22e in the centre of the upper disc 22b. The plunger may be made of metal or any suitable hard plastics material.

80 A bracket 26 mounted on the upper disc 22b carries a micro-switch 27 of the normally open type which is so disposed that its operating button 27a is capable of being depressed by the plunger 25 when the latter moves upwardly due to the displacement or deformation of the diaphragm by the pressure of water admitted to the heater when the inlet valve is opened.

85 The plunger 25 is urged away from the button 27a by means of a spring 28, one end of which engages the downwardly presented surface of the micro-switch immediately adjacent the button, and the other end of which engages a circular flange or projection 25a formed on or attached to the plunger. The micro-switch controls the supply of electricity to the heater and the circuit is only completed when the pressure exerted on the diaphragm exceeds a particular value which is determined by the material from which the diaphragm is made and the strength of the spring.

90 A terminal block 29 having a number of electrical connections is also mounted on the bracket 26. This serves to make appropriate connections between the mains electricity supply wires 30, the micro-switch 27, a heating element 31 in the heating tube 20 and the neon pilot light 15. Alternatively the terminal block 29 may be secured to the body, for example the rear wall 10 thereof.

95 The live lead 30l of the mains electricity supply is connected to one terminal 27b of the micro-switch 27 by wire 32 and the

neutral lead 30n is connected to one end of the heating element 31 by wire 31 and to one side of the neon pilot light 15 by wire 34. An earthing connection 35 is also made to this bracket by way of a screw 35a by means of which the terminal block 29 is mounted on the bracket. Alternatively an earth connection can be made by means of a circlip brazed to the tube 18 which is connected to the inlet pipe. The other terminal 27c of the micro-switch is connected to the other end of the heating element 31 by way of wire 36 and also to the other side of the pilot light by wire 37.

When the inlet valve 14 is opened water flows along the branch 17a into the heating tube 20, and the diaphragm 23 is deformed so that the plunger 25 is displaced by a distance dependent upon the water pressure in the chamber 21. When this pressure exceeds the predetermined value the plunger depresses the button of the micro-switch and the heating element is thus energized.

The thin walled copper tube of which the heating tube 20 is made is of circular shape in cross-section and is coiled into a helical form, as seen in Figures 1 and 4, the inlet valve 14, chamber 21 and micro-switch 27 collectively forming a single control unit which is disposed centrally of the helix. The heating element 31 comprises a length of resistance wire 31a within a thin walled copper tube 31b which is filled with a non-conducting mineral 31c such as powdered magnesium oxide.

The heating element 31 is disposed coaxially in the heating tube 20, the diameter of the heating element 31 being approximately half that of the latter. The heating element is somewhat longer than the heating tube so that it projects beyond that tube at both ends. The electrical connections to the element are made at the parts thereof which project longitudinally out of the tube.

A length of copper wire 38 of circular shape in cross-section is wound around the element 31 in contact with both the outer surface of the latter and the inner surface of the heating tube 20 so as to form a continuous helical fin around the element. However, it will be understood that an interrupted fin may be used if required. This ensures, in either case, that the heat generated by the element is dissipated over a large surface area and also ensures that the length of the flow path of the water around the heating element is sufficient for rapid heating as is necessary for continuous flow type heaters.

Furthermore the helically coiled wire 38 around the heating element 31 strengthens the heating tube 20 as a whole so that it may readily be manipulated and bent into the desired form after the heating element has been inserted without causing the tube 20

to collapse or become constricted. Insertion of the element into the tube is also facilitated by the provision of this round section wire.

Moreover it is believed that the deposition of mineral substance which occurs when hard water is heated (a phenomenon generally known as "furring") will take place primarily in the crevices indicated at 39 formed between the curved surfaces of the wire and the surfaces of the heating element and outer tube tangential thereto. Whereas if the wire were of rectangular cross-section it is expected that furring would occur over a greater area and cause greater restriction to the flow of water along the tube. Thus it is anticipated that the use of round wire will materially increase the useful life of the heating tube. However, wire which is of other than round section may still usefully be employed since the other advantages referred to above can still be obtained.

The heating tube 20 may be closed at each end by means of a length of tubing bent to form an elbow, one limb of which is externally screw threaded and connected to the connecting tube 18, and the other limb of which is brazed or soldered on to the end of the heating tube. A hole is then provided in the face of the elbow opposite to the end of the heating tube through which the heating element projects.

Preferably however, the ends of the heating tube 20 are closed by headed bushes 40 which are screwed into couplings 41 provided at the ends of the connecting tube 18 and the outlet tube 42 at opposite ends of the heating tube. The head 40a of each such bush 40 is provided with a bore 4 transverse to the bore 44 through the bush itself. The diameter of this transverse bore is for approximately half its length equal to the external diameter of the heating tube 20 which is soldered or brazed therein at 43a. The remainder of the length of the bore 43 is of a diameter equal to that of the heating element 31 which passes through the bore and is soldered or brazed therein as 43b.

The outlet tube 42 of the heating tube is connected at its other end to a T-piece 45 which is fixed in the outlet aperture 12 in the body. One arm 45a of this T-piece, namely that which extends through the cylindrical wall of the casing, serves as the connection 12a to a water outlet pipe (not shown) which may be mounted in known manner so as to swivel to any desired position.

The remaining arm 45b of the T-piece contains a pressure relief valve 46 comprising a ball 46a urged by spring 46b onto seating 46c. A small hole is provided in the casing near the pressure relief valve to permit drainage of any water discharged by that valve. If desired a hood (not shown) may be provided over the outlet of the pres-

sure relief valve so as positively to prevent any water discharged thereby coming into contact with the electrical connections in the centre of the heater.

- 5 The domestic water heater described typically has a body approximately 9 inches in diameter and 3 inches in depth. The diameter of the heating tube is typically  $\frac{3}{8}$  inch to  $\frac{1}{2}$  inch and it is some  $3\frac{1}{2}$  feet in length and  
10 coiled into convolutions approximately 8 inches in diameter. The heating element has a diameter of typically  $\frac{5}{16}$  to  $\frac{1}{4}$  inch in diameter. This heating element has a power  
15 dissipation of the order 3.7 kilowatts, which is normally sufficient to raise the temperature of the water from normal mains supply temperature (40—50°F) to any temperature up to boiling depending upon the flow rate.

- 20 The pressure required to be exerted on the diaphragm in order to actuate the micro-switch is normally in the range 0.4 to 0.5 pounds per square inch and the pressure relief valve in the T-piece normally operates at a pressure of the order 5 to 10 pounds  
25 per square inch. However, it is to be understood that these values may be varied to suit the particular circumstances.

- Under typical domestic conditions the output of the heater is approximately 4 pints  
30 per minute raised to a temperature of 85°F or 2 pints per minute raised to a temperature of 145°F.

- Various other optional features may be incorporated into such a heater in addition  
35 to those previously described. Thus, for instance, a temperature responsive device may be provided near the outlet 12a of the heater to de-energise the heating element 31 should the temperature of the water leaving the  
40 heater exceed a predetermined value. Furthermore a further micro-switch may be provided in conjunction with the pressure relief valve 46 to de-energise the heating element 31 should this valve operate.

- 45 Means for varying the extent of compression of the spring 28 which acts upon the plunger 35 which co-operates with the diaphragm 23 to operate the micro-switch 27 could be provided so that the pressure required to cause the heating element 31 to  
50 be energised could be varied according to the water pressure normally available in the locality in which the heater is to be used.

- For larger heaters in which a larger  
55 volume of water is required it would be possible to have several heating tubes 20 connected in parallel.

- 60 In an alternative arrangement the body 10 may be of squared or rectangular form as viewed frontally the top surface being of flat form to act as a shelf for holding articles. The cover 13 may incorporate a mirror presented forwardly at its front face or formed of a metal capable of being

polished to act as a mirror and including a flat portion for this purpose.

A further modification is that the inlet valve 14 may be disposed externally of the body, for example beneath this. The pipe 17 would then be disposed mainly above the inlet valve and would extend upwardly through the body to communicate with the branch 17a at the position illustrated at Figure 4 and with the interior of the diaphragm chamber as shown.

#### WHAT I CLAIM IS:—

1. A heater of the kind specified characterised in that the liquid flows through a heating tube in close thermal contact with the electric heating element which comprises a length of resistance wire insulated by mineral substance contained in a thin walled metal tube coaxially arranged within the heating tube, the supply of electricity to the heating element being controlled by a pressure sensitive device which is responsive to the pressure of liquid within the heater.

2. A heater according to claim 1 wherein the heating element is retained centrally in the heating tube by a continuous or interrupted fin which is disposed helically around the heating element and in contact with the latter and the inner surface of the heating tube.

3. A heater according to claim 2 wherein the fin comprises a length of wire of circular shape in cross-section which is wound around the heating element.

4. A heater according to any one of the preceding claims wherein the diameter of the heating element is approximately half the internal diameter of the heating tube, and the length of the former is slightly greater than that of the latter so that it projects out of the latter at each end for a short distance such that electric connections may be made at the projecting parts, the liquid entering and leaving the heating tube in directions substantially at right-angles to the longitudinal axis of the latter.

5. A heater according to claim 4 wherein liquid is supplied to or conveyed from the ends of the heating tube by way of a connecting piece at each end thereof, each connecting piece comprising a hollow stem provided with a head having a transverse bore which communicates with the interior of the stem, said transverse bore having over approximately half its length an internal diameter equal to or slightly greater than the external diameter of the heating tube which is inserted therein and over the remainder of its length an internal diameter equal to or slightly greater than the external diameter of the heating element which extends through the bore.

6. A heater according to any one of the preceding claims wherein the pressure sen-

5 sitive switch device is a switch means of the  
 "normally open" type having an operating  
 member of which is in operable contact with  
 a displaceable or deformable diaphragm in  
 a chamber connected to an inlet pipe which  
 incorporates the inlet valve and is formed  
 with a fitting for connection to the liquid  
 supply pipe, and the arrangement being such  
 that the heating element is not energised  
 10 until a predetermined minimum pressure is  
 exerted on the diaphragm.

7. A heater according to any one of the  
 preceding claims which is provided with a  
 pressure relief valve situated at or near the  
 15 outlet such that if an excessive pressure  
 arises within the heater due either to block-  
 age of the outlet pipe or over heating of the  
 liquid to form a vapour lock this valve is  
 opened to relieve the pressure.

20 8. A heater according to claim 7 wherein  
 switch means are provided in operative asso-  
 ciation with the pressure relief valve such  
 that the heating element is de-energised when  
 said valve is opened.

25 9. A heater according to any one of the  
 preceding claims wherein a temperature re-  
 sponsive device is provided near the outlet  
 of the heater to de-energise the heating  
 element if the temperature of the liquid de-  
 30 livered by the heater exceeds a predetermined  
 value.

10. A heater according to claim 6 or any  
 one of claims 7 to 9 as appendent there-  
 to wherein the predetermined minimum pres-  
 35 sure which is required to be exerted on the  
 diaphragm to energise the heating element is  
 provided by spring means acting in opposi-  
 tion to movement of the operating member  
 of the switch means tending to close said  
 switch means. 40

11. A heater according to claim 10 where-  
 in the spring means are adjustable so as to  
 vary the pressure which is required to be  
 exerted on the diaphragm to energise the  
 heating element. 45

12. A heater according to any one of the  
 preceding claims wherein the heating tube is  
 formed into a coil, loop, frame or like aper-  
 tured heating unit and disposed in the aper-  
 ture thus afforded is a control unit compris-  
 50 ing the inlet valve and a pressure sensitive  
 switch device for controlling energisation of  
 the heating element.

13. A heater substantially as hereinbefore  
 described with reference to and as shown 55  
 in the accompanying drawings.

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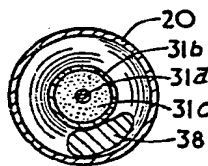


Fig. 2

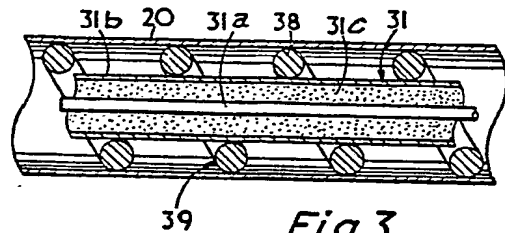


Fig. 3

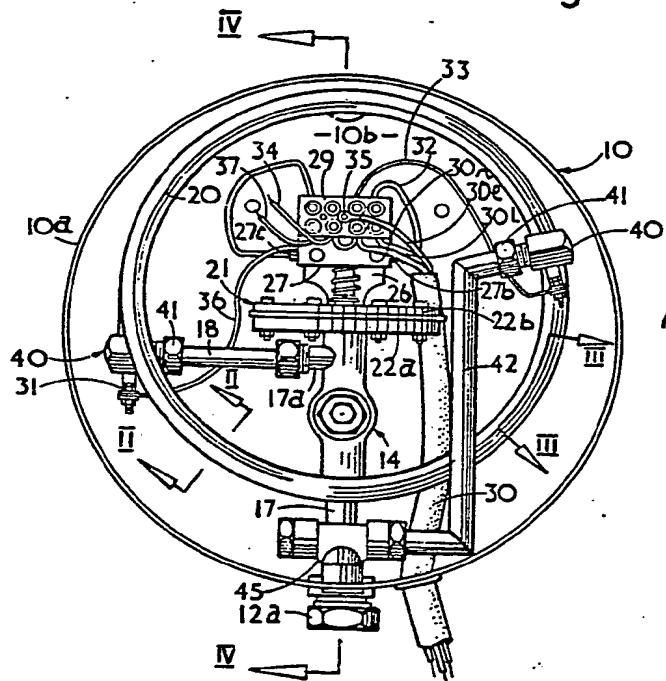


Fig. 1

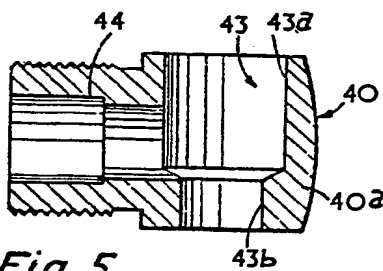


Fig. 5

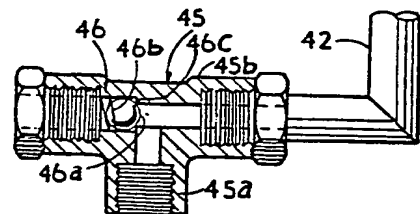


Fig. 6

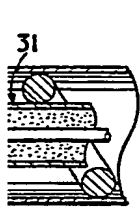


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COMPLETE SPECIFICATION

2 SHEETS

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the Original on a reduced scale  
Sheets 1 & 2



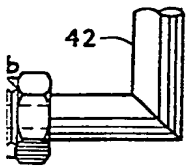
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Fig. 1



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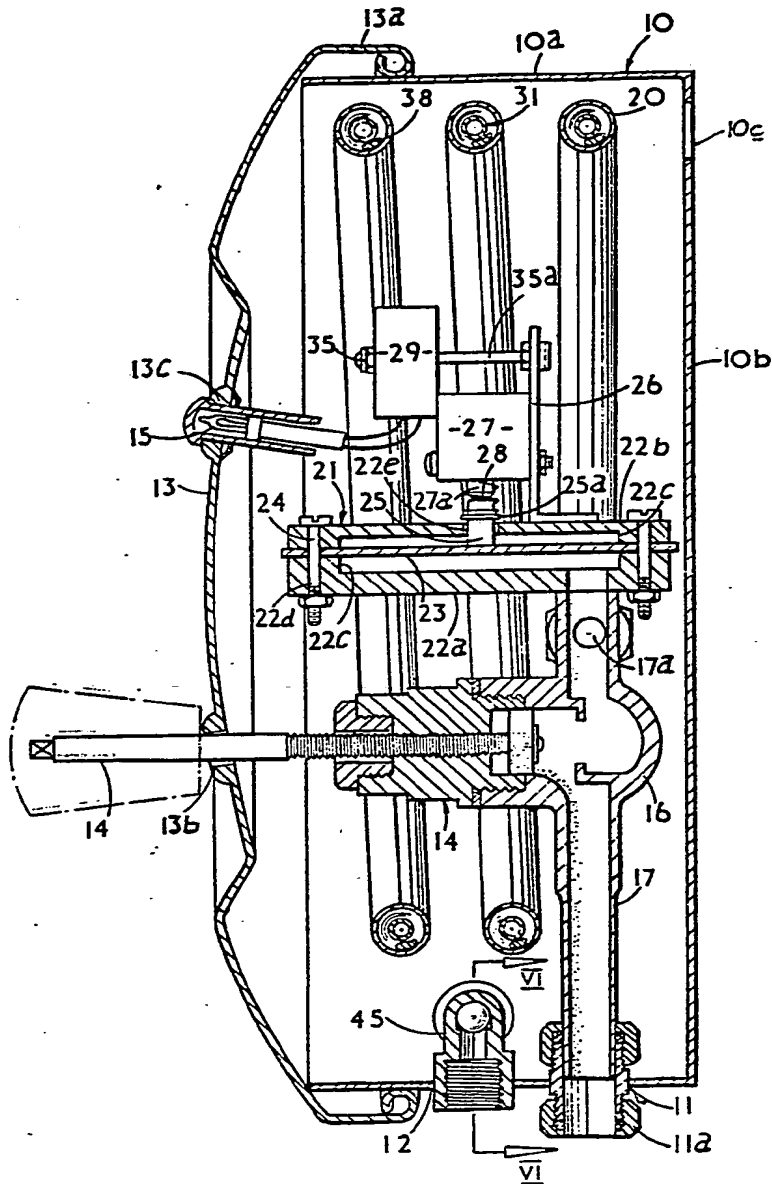


Fig. 4.

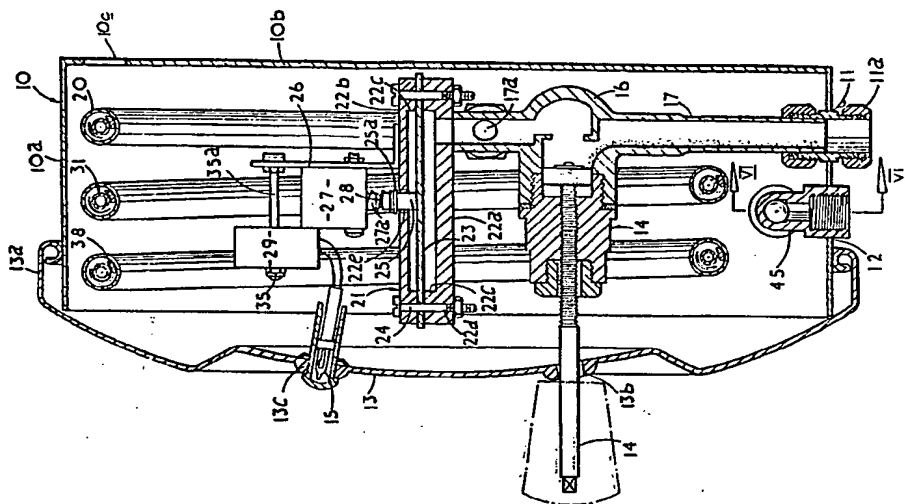


Fig. 4.

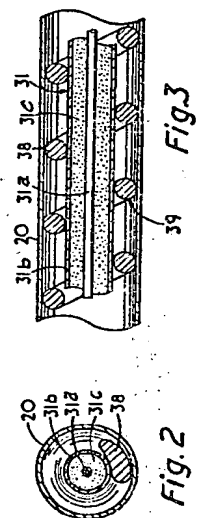


Fig. 2

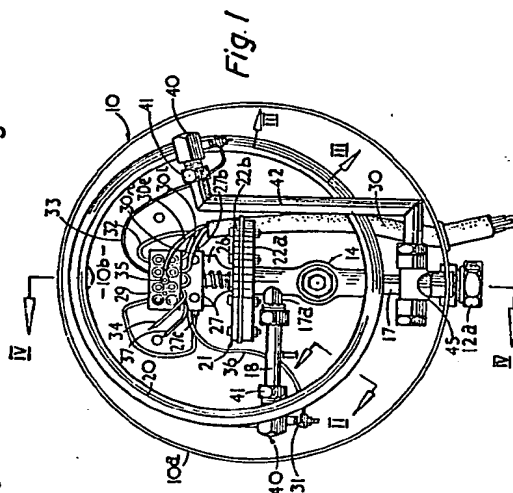


Fig. 1

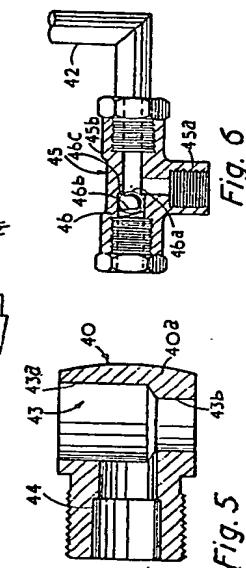


Fig. 5

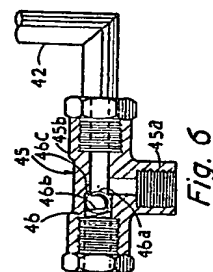


Fig. 6